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(54) **PLUG CONNECTOR**

(57) The present invention relates to a plug connector (100) for accommodating a cable head (130) and for being inserted into a socket (160). The plug connector (100) can be used for economically and feasibly integrating shielded cables into unshielded data communication systems, for example for sensitive links in automotive applications where a high electromagnetic compatibility (EMC) is required. The plug connector comprises a plug connector frame (110) and a connection member for electrically conductively connecting the shielding elements of the socket and the cable head (130). Advantageously, the connection member is a spring element (120) made of a resilient material having two contacting portions for electrically conductively contacting shielding elements of the cable head (130) and the socket (160). A method for manufacturing a plug connector is also provided.

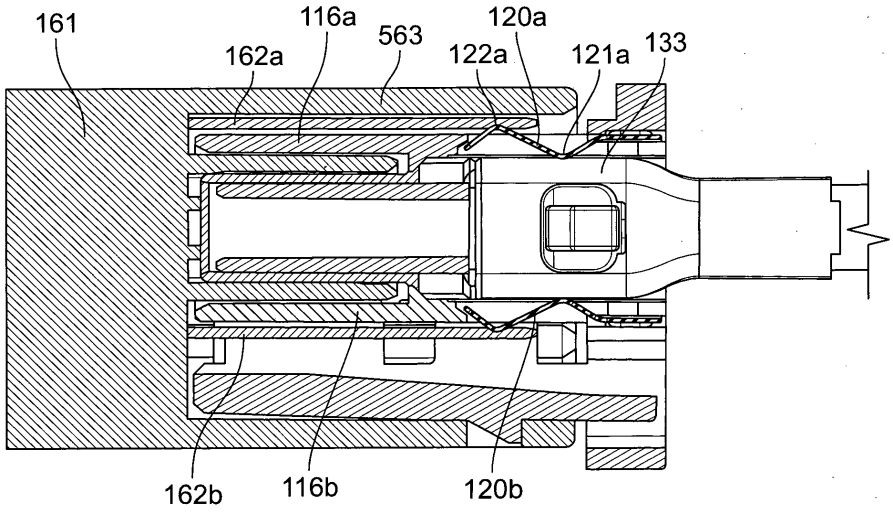

Fig. 5

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Description

BACKGROUND OF THE INVENTION

[0001] Recent developments of single twisted pair Ethernet physical layers for 100Mbit/s and 1Gbit/s automotive applications and in particular the in-car deployment allow new data communication architectures with capability of accommodating a large number of communication nodes. While unshielded twisted pair (UTP) cabling is the most economical solution for large quantities of Ethernet ports to be deployed, the electromagnetic compatibility (EMC) performance of the UTP is limited. Accordingly, a specific electrical design of all components is necessary for achieving sufficient EMC when using the UTP.

[0002] For example, TE Connectivity's MATEnet connector platform addresses those needs and provides an automotive solution for unshielded cabling as described in DiBiaso, E., Bergner, B., Wuelfing, J., Wuerker, R. et al., "Designing a Connection System for Gigabit Automotive Ethernet," SAE Int. J. Passeng. Cars - Electron. Electr. Syst. 9(1):134-146, 2016, doi:10.4271/2016-01-007. However, there are some sensitive Ethernet links in some car platforms where the emitted electromagnetic noise needs additional suppression. For instance, a car with a front facing camera mounted above the rear view mirror may also integrate the AM, FM and digital radio broadcast antennas in the windshield in close proximity to the camera. In this case, the performance of these wireless systems may be degraded by the network camera connection even if a high performance UTP system is used.

[0003] One possible approach would be the use of a fully shielded connector system instead of an unshielded system. However, the use of different connector platforms in the same Ethernet system increases the component variance and typically leads to increased costs. Using a fully shielded system for all Ethernet links could also be an alternative approach, but it is likely to be even more expensive.

SUMMARY OF THE INVENTION

[0004] In view of the above, the aim of the present invention is to provide a platform in which shielded and unshielded system components can be efficiently deployed.

[0005] This is achieved by the features as set forth in the independent claims.

[0006] Preferred embodiments are the subject matter of dependent claims.

[0007] In particular, a plug connector is provided which is capable of interconnecting shielding of a socket and a shielding of a cable to be plugged into the socket. Such a plug connector allows to combine shielded cables and unshielded connector systems in an economic and feasible way and secures sufficient EMC for sensitive links.

[0008] According to an aspect of the present invention, a plug connector is provided for being inserted into a socket and for accommodating a cable head. The plug connector comprises a plug connector frame having a side wall and a front opening for accommodating the cable head, a spring element made of a resilient material for electrically connecting the cable head and the socket. The spring element has: a first contacting portion projecting inwards above the side wall of the plug connector frame for electrically conductively contacting the cable head, and a second contacting portion projecting outwards above the side wall of the plug connector frame for electrically conductively contacting the socket. The first contacting portion and the second contacting portion are directly and electrically conductively connected.

[0009] Advantageously, the spring element is formed as a flat spring having two bends, the bends oriented to opposite directions, and the contacting portions being located at the bends.

[0010] The two contacting portions may be bulges coined into the spring element at the bends, wherein the bulge constituting the first contacting portion is oriented towards the interior of the plug connector frame and the bulge constituting the second contacting portion is oriented towards the exterior of the plug connector frame. This provides for a more precise arrangement of contacting portions.

[0011] According to an embodiment, the spring element comprises a flat end portion fitted into a portion of the plug connector frame adjacent to a front face including a front opening, and a protrusion for fixing the spring element in the plug connector frame, the protrusion projecting from a surface of the flat end portion.

[0012] Advantageously, the protrusion projecting from the flat end portion of the spring element is a bulge coined into the flat end portion of the spring element.

[0013] According to an embodiment, a tooth protrudes from a rim of the flat end portion of the spring element for fixing the spring element into the plug connector frame, the tooth being at least partially pressed into the material of the plug connector frame.

[0014] For instance, the spring element is made of a single piece of the resilient material. This provides higher mechanical stability and enables an efficient production.

[0015] The material of which the spring is made may be metal.

[0016] Advantageously, a contacting portion of the spring element is plated, wherein the material of the plating has a higher electrical conductivity than the material of which the spring element is made. A plating with a material having high electrical conductivity may improve the shielding functionality of the plug connector since the resistance at the contacting portion(s) is reduced.

[0017] The plug connector frame may have a front gap for inserting the spring element. This allows for an easy inserting of the spring element into the plug connector. For instance, the front gap and the front opening of the plug connector frame are joined, which may provide for

easier production of the plug connector frame.

[0018] Moreover, the first contacting portion and the second contacting portion of the spring element emerge over the side wall through a side wall opening, the side wall opening and the front gap being joined.

[0019] Advantageously, the plug connector comprises a second spring element fitted into a second side wall of the plug connector frame on the opposite side of the plug connector frame from the side wall into which the first spring element is fitted. Accordingly, the EM field generated by a current passing the cable head becomes symmetric, which on the other hand prevents occurrence of parasite capacitances.

[0020] According to another aspect of the present invention, a plug connector system is provided, comprising a socket, a cable head of a shielded cable, and a plug connector as described above. Advantageously, the socket comprising a shielding element made of an electrically conductive material, the cable head comprising a shielding element made of an electrically conductive material, and the spring element of the plug connector electrically connecting the shielding element of the socket and the shielding element of the cable head. The plug connector may detachably insertable into the socket and the cable head is non-detachably inserted into the plug connector, when implemented on board.

[0021] According to another aspect of the present invention, a method is provided for manufacturing a plug connector. The method comprises the steps of providing a plug connector frame having a front opening for accommodating a cable head, a front gap for inserting a spring element, and a side wall, providing a spring element made of a resilient material for electrically conductively connecting the cable head and the socket, the spring element having a first contacting portion for electrically conductively contacting the cable head and a second contacting portion for electrically conductively contacting the socket, the first contacting portion and the second contacting portion pointing into opposite directions and being directly and electrically conductively connected, and inserting the spring element into the plug connector frame through the front gap so that the first contacting portion projects inwards above the side wall of the plug connector frame and the second contacting portion projects outwards above the side wall of the plug connector frame, reversibly deforming the spring element during insertion.

[0022] The accompanying drawings are incorporated into and form a part of the specification to illustrate several embodiments of the present invention. These drawings together with the description serve to explain the principles of the invention. The drawings are merely for the purpose of illustrating the preferred and alternative examples of how the invention can be made and used, and are not to be construed as limiting the invention to only the illustrated and described embodiments. Furthermore, several aspects of the embodiments may form - individually or in different combinations - solutions according to the present invention. The above explanation and other objectives and features of the present invention will become more apparent from the following description and preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1	is a perspective drawing of the components of a socket, a plug connector and a cable head detached from each other.
Fig. 2	is a perspective drawing of a plug connector accommodating a cable head and a socket being detaches from the plug connector frame.
Fig. 3	is a cross section of a plug connector accommodating a cable head.
Fig. 4	is a perspective view of a plug connector system with a socket accommodating a plug connector and the plug connector accommodating the cable head.
Figs. 5-7	are cross sections of the plug connector system with a socket accommodating a plug connector and the plug connector accommodating the cable head.
Fig. 8	is a perspective view of a cross section of a plug connector system with a socket accommodating a plug connector and the plug connector accommodating the cable head.
Fig. 9	is a perspective drawing of an arrangement of a cable head and two spring elements being inserted into a plug connector frame.
Fig. 10	is a perspective drawing of a plug connector with two spring elements detached from the plug connector frame and a plug connector with two spring elements inserted into the plug connector frame.
Fig. 11	is a cross section of the plug connector system with a socket accommodating a plug connector and the plug connector accommodating the cable head showing a surface of .a spring element.
Fig. 12	is a perspective drawing of a type of spring element for use in a plug connector.
Fig. 13	shows the three different sides of a spring element according to Fig. 12.
Fig. 14	is a perspective drawing of a type of spring element alternative to the type shown in Figs. 12 and 13.

Fig. 15 shows the three different sides of a spring element according to Fig. 14.

Fig. 16 is a flow chart explaining a method for manufacturing a plug connector.

Fig. 17 illustrates the manufacturing step of inserting spring elements into a plug connector frame.

Fig. 18 shows test results of an EMC performance test for shielded and unshielded cables.

DETAILED DESCRIPTION

[0023] The present invention provides a plug connector for enhancing EMC when shielded cables are paired with unshielded connectors.

[0024] According to an aspect of the present invention, a plug connector is provided which interconnects the shielding elements of a socket and a cable. With such a plug connector, existing sockets originally used in unshielded applications can be used both for shielded and unshielded cables. Shielded and unshielded cables can therefore be easily exchanged and combined.

[0025] Such a plug connector comprises an interconnection member which passes through the wall of the connector and is arranged to interconnect the cable head and the socket in the plugged state. The interconnection member includes an electrically conductive portion for connecting the cable head and the socket. Advantageously, the interconnection member is a resilient spring element made of a resilient material which ensures that the plug connector can be plugged and unplugged to/from the socket without deteriorating the quality of the conductive connection. The resilient spring, on the other hand, establishes durable electrical contact with the cable head. A perspective view of the components of a plug connector system according to an embodiment of the present invention is shown in Figure 1. In particular, the plug connector system comprises a socket 160, a cable head 130 and a plug connector 100.

[0026] The socket 160 may correspond to the board connector of the above mentioned MATEnet platform. The cable head 130 is mounted on a cable 131. Thus, the cable is terminated with a terminal corresponding in shape to the board connector. The cable head of a shielded cable also has shielding. The cable may be for instance, a shielded twisted pair (STP) cable.

[0027] In comparison with the existing plug connectors such as the MATEnet platform, the plug connector 100 is modified to accommodate one spring element or more additional spring elements which are capable of interconnecting the shielding elements of the cable 131 or cable head 130 and the socket 160. This enables the same board connectors and fixtures for both UTP and STP cables to be used with the same plug connector.

[0028] This can be seen in Figure 1, in which the plug connector 100 comprises a plug connector frame 110 and a spring element 120 for electrically connecting the cable head 130 and the socket 160. The plug connector frame comprises a front face 112. It further comprises a side wall 116. In the side wall 116 of the plug connector frame 110, there is an opening 117. In the front face 112 of the plug connector frame, there is a front opening 113 for accommodating the cable head 130. Furthermore, in the front face 112 of the plug connector frame 110, there is a gap 114 for inserting the spring element 120. The gap 114 and the side wall opening 117 are joined.

[0029] In Figure 1, the gap 114 has the shape of two grooves 115a, 115b embedded into the front portion 111, i.e. the portion adjacent to the front face 112. The grooves 115a, 115b run from the front face 112 to a position where the front portion 111 meets the side wall 116. The grooves 115a, 115b are located at the edge of the front opening 113. Thus, the gap 114 for inserting the spring element 120 and the front opening 118 for accommodating the cable head 130 are joined. In other words, the front gap 114 and the front opening 113 form a cavity. This cavity is divided into the front gap 114 and the front opening 113 through a pair of opposite rails at the cavity walls, the gaps delimiting the grooves 115a, 115b.

[0030] It is noted that this arrangement is exemplary. In general, the plug connector 100 does not necessarily include a separate front portion 111 set apart from the remaining portion of the plug connector frame. In Figure 1, the front portion 111 is formed as a sleeve which has rounded corners and overhangs the side walls of the frame on all sides. The width of the front portion 111 in Figure 1 allows for robustly embedding the grooves 115a, 115b for inserting the spring element 120. Nevertheless, the present invention is not limited thereto and in general, the spring element 120 may be accommodated in any other way.

[0031] The side wall opening 117 forms an open space, in which the contacting portions 121, 122 emerge in the respective inward and outward directions above the side wall 116. However, a side wall opening may also serve for inserting the spring element, for instance, from outside of the plug connector frame. In such arrangement, no groves are necessary at the front face; instead, some grooves or a slot or other means may be provided inside the side wall for fixing the spring element.

[0032] The spring element 120 in Figure 1 is fitted into the opening 117 in the side wall 116 of the plug connector frame 110. The spring element 120 is made of a resilient material and may be made partially or entirely out of an electrically conductive material. It has a first contacting portion 121 for electrically conductively contacting the cable head, and a second contacting portion 122 for electrically conductively contacting the socket 160. The portion of the spring element 120 connecting the first contacting portion 121 and the second contacting portion 122 is located at least partially inside the side wall opening 117 of the plug connector frame 110. In other words, it crosses the plane of the side wall 116 in the opening

117. In particular, the first contacting portion 121 emerges inwards over the side wall 116 of the plug connector frame 110, whereas the second contacting portion 122 emerges outwards over the side wall 116 of the plug connector frame 110, through the side wall opening 117.

[0033] In Figure 1, the second contacting portion 122 located closer to the front face 112 protrudes from the plug connector through the side wall inwardly while the first contacting portion 121 located farther from the front face 112 protrudes from the plug connector through the side wall outwardly. However, practically, the closer contacting portion 122 may also protrude outwardly while the farther contacting portion 121 may protrude inwardly.

[0034] In an embodiment of the present invention, the cable head 130 is the cable head of the shielded cable 131, for example a STP cable. The cable head 130 comprises a fixation element 132 with a crimp section 133. The fixation element 132 is made of an electrically conductive material such as metal. Made of an electrically conductive material, the fixation element 132 serves as a shielding element. The cable head further comprises a contact insert 134 embedding the contacts for electrically connecting the wires of the cable with the socket. Advantageously, the contact insert is made, for example, of plastic. A plate 162 made of an electrically conductive material such as metal is fitted into the body 161 of the socket 160. For the purpose of the present invention, the particular form and structure of the cable is not limiting. The plug connector

[0035] In Figure 1, the components of the plug connector system are detached from each other for illustrative purposes. In use, the cable is embedded in the plug connector and the plug connector is detachably connected being plugged in the socket.

[0036] Accordingly, Figure 2 shows the socket 160 being detached from the plug connector 100 and the plug connector accommodating the cable head 130. The plug connector frame has four side walls, two pairs of opposite side walls. Adjacent side walls are perpendicular, and the edges between adjacent side walls are rounded so that the four walls with the rounded edges enclose the front portion / face portion of the connector. However, the plug connector frame may have different forms since its form is not essential for the invention. For instance, instead of having four side walls, the side wall of the plug connector frame may be single round side wall of a cylinder or it may have more or less than four walls with or without rounded edges. In accordance with the plug connector having a cylindrical side wall, the socket and the cable head of the plug connector frame may have a round cross-section. The embedding of the cable head in the plug connector may be achieved by means of a fixing means 234. The fixing means may have the shape of a barbed hook cut into the plug connector frame which is clipped to a corresponding open space in the plug connector wall after the cable head has been inserted into the plug connector.

[0037] A cross-section of the plug connector accommodating the cable head is shown in Figure 3. The plug connector includes two spring elements 120a and 120b on two opposite side walls 116a, 116b. However, the spring elements may be arranged in a different manner. There may be, for example, four spring elements on four side walls of the plug connector frame. In a case with only one side wall, for example a round side wall resembling the side wall of a cylinder, the spring element may be located on opposite portions of the single side wall.

[0038] The spring element 120a is fitted into the side wall 116 of the plug connector frame 110. The spring element 120a is formed as a flat spring. The spring element 120a has two contacting portions 121 a and 122a. The first contacting portion 121 a projects inwards over the side wall 116 of the plug connector frame 110. The second contacting portion 121b projects outwards over the side wall of the plug connector frame 110. As the plug connector accommodates the cable head, the first contacting portion 121a conductively contacts the crimp section 133 of the cable head. The first contacting portion 121 a is located on a first bend 333 of the spring element, and the second contacting portion 122a is located on a second bend 334.

[0039] However, in general, this arrangement is not to limit the present invention. The purpose of the spring element is to provide, in the plugged state, an interconnection between the socket shielding and the cable shielding. For this general purpose, the spring element may have any form including two contacting portions formed as needle-like protrusions, possibly having a contacting head located on a plate.

[0040] Preferably, the first contacting portion 121a and the second contacting portion 121b are directly and electrically conductively connected. In particular, there is advantageously no loop or winding between the first contacting portion and the second contacting portion. As there is no loop or winding, the presence of unintended inductors is circumvented, which may otherwise deteriorate EMC. The direct connection between the first contacting portion 121a and the second contacting portion 121b in Figure 3 resembles a straight line. However, provided that there are no loops or windings, the direct connection between the first contacting portion 121 a and the second contacting portion 121 b may deviate from a straight line and may, for instance, be bent or slightly curved. In addition, due to the force exerted by the crimp section 133 on the spring element 120a, the spring element may be deformed.

[0041] The spring element 120a comprises a flat end portion 323a fitted into the front portion 111 of the plug connector frame. The flat end portion 323a has a form of a plate, in particular, a rectangular plate. Advantageously, the width of the flat end portion 323a corresponds to the width of the front gap for inserting the spring element. As the form of the flat end portion 323a is immaterial for the invention, it may be different. It may be, for example, a trapezoidal plate. By means of the flat end portion, the spring element is fitted into the front gap 112

of the plug connector frame. However, a spring element according to an embodiment of the present invention may alternatively have no distinct flat end portion and may be simply fitted by its flat end into the connector frame either in the front portion or in a side wall.

[0042] The faces of the flat end portion 323a are oriented (substantially) parallel to the side wall 116a of the plug connector frame. At its rim, the flat end portion 323a is fitted into the groove 115a of the plug connector frame. A protrusion 324a projects from the flat end portion 323a of the spring element 120a and enables thereby fitting the spring element into the plug connector frame. The protrusion 324a allows the spring element 120a to be tightly fitted. Accordingly, the spring element 120a is fixed in the plug connector frame although the width of the groove 115a exceeds the thickness of the spring element 120a, preventing the flat end portion 323a from hanging loose and dangling. In other words, the protrusion 324a fixes the end portion 323a and thus the entire string within the plug connector. A typical reason why the groove 115a exceeds the thickness of the spring element 120a is that tools for engraving thicker grooves are more robust which enables a more cost and time efficient production. Advantageously, the protrusion 324a is a bulge coined into the flat end portion 323a of the spring element 120a.

[0043] The narrow end portion 325a of the spring element 120a (at the opposite end of the spring element 120a with respect to the flat end portion 323) adjoins the edge 317a of the side wall opening 117 opposite of the end of the side wall opening 117 where the side wall opening 117 and the front gap 114 are joined. The edge 317a of the side wall opening, which the narrow end portion 325a of the spring element adjoins, is inclined inwardly. This inward inclination reduces the movement freedom of the spring element 120a. In other words, in the inside of the connector frame 110 there may be a frame member for stopping / fixing the narrow end portion 325a of the spring element.

[0044] In an embodiment of the present invention shown in Figure 3, the plug connector comprises a second spring element 120b. The second spring element 120b is fitted into a second side wall 116b which is different from the first side wall 116a into which the first spring element 120a is fitted. Advantageously, the second side wall 116b is a side wall opposite of the first side wall 116a into which the first spring element 120a is fitted. The first side wall 116a is an outer side wall of the plug connector frame. In contrast, the second side wall 116 b is not an outer side wall of the plug connector frame. It is covered by a further outer side wall 318. The first spring element 120a and the second spring elements 120b are symmetrically arranged around the cable head, enforcing the electromagnetic field of a current being carried by the cable head to be symmetric. The plug connector frame may alternatively have only one spring element or more than two spring elements. Advantageously, for the enforcement of a symmetric electromagnetic field, the number of spring elements is two or a multiple of two, wherein at least one pair of spring elements is symmetrically arranged around the cable head.

[0045] In correspondence to the first spring element 120a, the second spring element 120b includes a first contacting portion 121 b, a second contacting portion 122b, and a flat end portion 323b from the flat surface of which a protrusion 324b projects. Its narrow end portion 325b is tangent to the edge 317b of the opening of the second side wall 116b. Thus, the spring is stop from further movement within the plug connector frame by touching the edge 317b. The above description of the first spring element 120a and its features analogously applies to the second spring element 120b.

[0046] Advantageously, the first side wall 116a and the second side wall 116b into which the spring element 120a, 120b are fitted, are opposite side walls of the plug connector frame.

[0047] In the Figures 2 and 3, the plug connector frame accommodates the cable head, but it is detached from the socket. On the other hand, in the Figures 4 and 5, the plug connector accommodates the cable head, and it is further inserted into the socket. This arrangement corresponds to the connection of socket, plug connector and cable head during use. Figure 4 shows a perspective view of the plug connector system. As can be seen in Figure 4, the socket 160 has the shape of a cuboid with a front, a back, and four side walls. The front and the back may have the shape of squares. Two side walls not located opposite of each other may have the same dimensions or may have different dimensions.

[0048] Figure 5 shows a cross-section of the plug connector system. The description of the features of the plug connector and the cable head as well as the engagements of the plug connector and the cable head, as shown in Figure 2, applies analogously to Figure 5.

[0049] The following description of Figure 5 relates to the socket and the engagement of the socket and the plug connector. The socket comprises a socket body 561 and a plate 162a. The plate 162a is made of an electrically conductive material. The plate 162a is parallel to the socket wall 563. As shown in Figure 3, the first contacting portion 121 a conductively contacts the crimp section 133 of the cable head. In addition, the second contacting portion 122a conductively contacts the plate 162a of the socket. As in Figure 3, the first contacting portion 121a and the second contacting portion 121b are directly and conductively connected. Due to the forces exerted on the spring element by the crimp section 133 and the plate 162a, the spring element 120a may be slightly deformed. Thus, the direct connection between the first contacting portion 121 a and the second contacting portion 122a may deviate from a straight line.

[0050] As in Figure 3, the plug connector includes a second spring element 120b fitted into a second side wall 116b different from the first side wall 116a. Also, in Figure 5, the socket includes a second plate 162b which conductively contacts the second contacting portion 122b. The first plate 162a and the second plate 162 b are lo-

cated on opposite walls of the socket. Both the first spring element 120a and the second spring element 120b, and the first plate 162a and the second plate 162b, are symmetrically arranged around the cable head, enforcing the electromagnetic field of a current being carried by the cable head to be symmetric.

[0051] As in Figure 3, the first spring element 120a and the second spring elements 120b are symmetrically arranged around the cable head. Additionally, in Figure 5, the first plate 116a and the second plate 116b are parallel and symmetrically arranged around the cable head.

[0052] Figure 6 and 7 show cross-sections of a plug connector system according to an embodiment of the present invention In contrast to the Figures 3 and 5, the current carriers 634a, 634b (wires) inside the cable and the cable head are displayed. In an embodiment of the invention, the socket is used to accommodate a plug connector frame for a shielded cable, in particular in STP cable. However, an identical socket can be used in a connector system of an unshielded cable such as a UTP cable. In connector systems for unshielded cables, symmetrical plates are intended to ensure low mode conversion (see the above cited document by *E. DiBiaso et al).* By using two symmetrical plates rather than one single plate, the build-up of an electric field between current carriers inside the cable head and the single metal plate is prevented. Accordingly, current carriers and the single conductive plate are prevented from unintentionally forming a capacitor.

[0053] As shown in Figure 6, the first contacting portions 121 a, 121 b of both spring elements 120a, 120b for contacting the cable head are located closer to the front portion 111 of the plug connector frame than the second contacting portions 122a, 122b. However, in an alternative embodiment, at least one of the spring elements may be fitted into the spring element upside down so that the contacting portion farther from the front portion 111 serves as the first contacting portion for contacting the cable head. In this case, longer contact plates 116a, 116b are required than shown in Figure 6.

[0054] When the socket is used for an STP cable, as in an embodiment of the present invention, the symmetrical and parallel plates 116a, 116b further serve as shielding elements of the socket. In particular, the plates 116a, 116b shield the electromagnetic field resulting from a current inside the cable head. Accordingly, the fixation element 132 with the crimp section 133 serves as a shielding element of the cable head. The spring element 120a conductively connects the shielding element of the socket with the shielding element of the cable head. A dash-dotted line 690 shown in Figure 6 symbolizes the path of the current running from the plate 116a of the socket through the spring element 120a to the fixation element 312 of the cable head. Through conductively connecting the shielding elements of socket and cable head, the spring element causes the shielding elements of the socket and the cable head to have the same electrical potential. As a consequence, electrical fields due to a difference in electrical potential between the shielding elements of socket and cable head are prevented from emanating from the plug connector. Therefore, a plug connector having a spring element for electrically conductively connecting a socket and a cable head enhances EMC of a plug connector system. The number of plates is not limited to two. There may be, for example, four plates on the four side walls of the socket.

[0055] Figure 8 shows a perspective view of a cross section of a plug connector system according to an embodiment of the present invention. As in Figure 5, the plug connector has two spring elements 120a, 120b fitted into plug side walls 116a, 116b, and the socket 160 has two plates 162a, 162b. The spring elements 120a, 120b are fitted into the side walls 116a, 116b of the plug connector frame. The first contacting portions 121 a, 121 b, of the spring element contacting the crimp section 133 of the cable head, are directly connected to the second contacting portions 122a, 122b contacting the plates of the socket 160. The crimp section of the cable head 133 and the plates 162a, 162b of the socket 160 exert forces on the spring elements 120a, 120b, deforming the spring elements 120a, 120b. These forces prevent the spring elements 120a, 120b from losing the conductive contact with the plates 162a, 162b and the crimp section 133. The edges of the flat and portions 323a, 323b of the spring elements 120a, 120b are fitted into the grooves 115a, 115c that constitute the front gaps for inserting the spring elements into the plug connector frame 120a, 120b.

[0056] Figure 9 shows an arrangement of the cable head, the spring elements 120a, 120b, and a side portion the plug connector frame. In comparison with Figures 1 to 8, the components of the plug connector system are shown upside down. Merely for demonstration, only the side portion of the plug connector frame is shown, as if cut off the remaining portion of the plug connector frame. By showing only a side portion of the plug connector frame, the groove 115d into which the edge of the flat end portion 323b of the spring element 120b is clearly visible. From the flat end portion 323b of the spring element 120b, protrusions 324c, 324d project. The protrusions 324c, 324d are bulges coined into the flat end portion 323b of the spring element 120b. Having a protrusion 324, the flat end portion fills the gap in the front portion 111 defined by the groove 115d of the plug connector frame although the width of gap exceeds the thickness of the flat end portion 323b of the spring element 120b.

[0057] Figure 10 is a two-part figure showing the plug connector according to an embodiment of the present invention. The subfigure on the left hand side of Figure 10 shows the plug connector frame 110 and the spring elements 120a and 120b being detached from the plug connector frame 110. The spring elements 120a, 120b face the front face 112 of the plug connector frame with the openings 114a, 114b for inserting the spring elements 120a 120b.

[0058] The spring elements 120a and 120b are arranged symmetrically with respect to each other. In other

words, the first contacting portions 121a, 121b of the two spring elements point towards each other, and the second contacting portions 122a, 122b of the two spring elements point away from each other. Furthermore, the narrow end portions 325a, 325b the are oriented towards the front face 112 of the plug connector frame. This relative arrangement of the spring elements 120a, 120b with respect to each other and with respect to the plug connector frame is in accordance with the assembly of the plug connector, wherein the narrow end portions 325a, 325b face the front face 112 of the plug connector frame 110 when spring elements 120a, 120b are inserted into the front gaps 114a, 114b of the plug connector frame. However, the invention is not limited to a symmetrical arrangement of the two spring elements. In an alternative embodiment, the spring elements may be arranged parallel, with identical faces being oriented to the same direction.

[0059] The subfigure on the right hand side of Figure 10 shows the plug connector 100 after the spring elements 120a, 120b have been inserted into the plug connector frame. One spring element 120a is fitted into the side wall 116a of the plug connector frame. The second contacting portion 122a emerges over the side wall 116a of the plug connector frame 110 through the side wall opening 117.

[0060] The gaps 114a, 114b for inserting the spring elements have the shape of grooves 115a, 115b, 115c, 115d embedded into the front portion 111. In an embodiment, the gaps 114a, 114b are joined with the front opening 113 for inserting the cable head. Alternatively, gaps for inserting the spring elements can have the shape of slots which are not joined with a front opening for inserting the cable head (not shown). From the front portion 111 of the plug connector frame to the middle of the side wall, the side wall opening 117 tapers. In particular, the side wall opening 117 has the shape of the trapezium, wherein the side joining the front portion 111 of the plug connector frame is longer than its opposite parallel side. The taper and the trapezoidal shape of the side wall opening 117 allow thicker walls in comparison with a rectangular side wall opening.

[0061] Figure 11 shows a cross-section of the plug connector system, with the plug connector being inserted into the socket 160 and the plug connector accommodating the cable head. The spring element 120 is fitted into the side wall 116 of the plug connector frame. In the cross-section of the plug connector system shown in Figure 5, the side wall 116a into which the spring element 120a is fitted is perpendicular to the plane corresponding to the paper/screen. In contrast, in Figure 11, the side wall 116 into which the spring element 120 is fitted, is parallel to the plane corresponding to the paper/screen. At opposite sides of the flat end portion 323 of the spring element 120, teeth 1129a, 1129b protrude from the rim of the flat end portion 323. The teeth 1129a, 1129b are pressed into the material of the plug connector frame for a strong fixation of the spring element 120 to the plug connector frame. The portion of the spring element 120 comprising the first contacting portion 121 and the second contacting portion 122 is located inside the side wall opening 117.

[0062] In an embodiment of the present invention, the spring element 120 is made of a conductive and resilient material, such as metal. For instance, the spring element may be made of stainless steel, such as X10CrNi18-8, to meet the requirement of resilience, although the electrical conductivity of steel may be limited. However, to compensate for the limited conductivity of the spring element material and/or to improve the electrical conductivity at the contacting portions, the first contacting portion, the second contacting portion, and/or the spring element portion between the first contacting portion may be plated with a material having a greater conductivity than the spring element material. The plating at the contacting portions may be, for example, a tin plating, a gold plating, or a nickel plating. If a sufficient conductivity between the first contacting portion, the second contacting portion, and on the two contacting portions is secured through the plating, the spring element may be made of a dielectric or a material with a low conductance, such as a non-metal.

[0063] The Figures 12 and 13 show one type of spring element intended for use in a plug connector system according to an embodiment of the present invention. Figure 12 shows a perspective view of the spring element 1220. Figure 13 shows side views of the three different sides of the spring element, wherein from one to the next subfigure, the spring element is rotated by 90°. The following description of the spring element 1220 refers both to Figure 12 and to Figure 13.

[0064] The spring element is made of a single piece of a conductive and resilient material. It is formed as a flat spring having a first bend 1223 and a second bend 1224 oriented to opposite directions. At the bends, there are protrusions projecting from the spring element. These protrusions are formed as round or oval bulges coined into the spring element at the bends 1223, 1224. The bulges constitute the first contacting portion 1221 and the second contacting portion 1222 of the spring element. When the spring element 1220 is fitted into the wall of a plug connector frame, the bulge constituting the first contacting portion 1221 of the plug connector frame is oriented to the interior of the plug connector frame, and the bulge constituting the second contacting portion 1222 is oriented to the exterior of the plug connector frame. Through these bulges, the first contacting portion 1221 and the second contacting portion 1222 are formed as point contacts. Such localized contacts allow a well defined, tight and secure contact of the spring element 1220 with the cable head and the socket, respectively. The invention is not limited to this particular shape of the protrusions. The protrusions may alternatively have the shapes of cones. Furthermore, different protrusions may project from the opposite surfaces of the plug connector frame. Instead of being coined into the spring element

material, they may be soldered onto the spring element material, or formed in any other way.

[0065] The spring element 1220 further comprises a flat end portion 1226 for being fitted into the plug connector frame at the front portion of the plug connector frame. There is a third bend 1225 between the flat end portion 1226 and the remaining portion of the spring element. The flat end portion 1226 is broader than the remaining portion of the spring element. The flat end portion 1226 has a form of a plate, in particular, a rectangular plate. From one surface of the flat end portion 1226, protrusions 1234a, 1234b are projecting. The two protrusions 1234a, 1234b are bulges having a prolate shape coined into the flat end portion 1226 of the spring element 1220. When the spring element 1220 is fitted into the plug connector frame, the protrusions 1234a, 1234b reduce the transversal movement of the spring element. Alternatively, there may be other arrangements of protrusions, such as, for example, one single bulge in the center of the flat end portion 1226, or four round bulges instead of two prolate bulges. Protrusions may further protrude from both opposite surfaces of the plug connector frame. On each of the longitudinal sides of the spring element 1220, a tooth 1229a, and respectively, 1229b protrudes from the rim of the flat end portion 1226, for being at least partially pressed into the material of the plug connector frame. The teeth 1229a, 1229b serve for fixing the spring element in the plug connector frame. In addition, the flat end portion 1226 includes guiding features 1237a, 1237b at the corners of the side which is first inserted into the plug connector frame.

[0066] The guiding features (members) 1237a, 1237b facilitate the insertion of the spring element into the plug connector frame. The guiding features have the shape of inclinations of the flat end portion 1226 at the corners on the side which is first inserted into the plug connector frame. However, the shape of the guiding features is may differ. The guiding features may, for example, be formed as rounded corners. Furthermore, the spring element 1220 has an opening 1228 between the flat end portion 1226 and the first contacting portion 1221 for controlling the stresses and forces being exerted on the spring element 1220, for example, when inserting the spring element into the plug connector frame. From the first contacting portion 1221 to the second contacting portion 1222, the spring element tapers in order to reduce forces and mechanical stresses being exerted on the spring element 1220. From the second contacting portion 1222 at the second bend 1224 to the narrow end portion 1236, the spring element gets wider again. This widening secures a tight engagement of the spring element 1220 to the side wall of the plug connector frame and reduces the movement of the narrow end of the spring element. However, the invention is not limited to this particular design. For example, instead of a taper between the first contacting portion 1221 and the second contacting portion 1222 and a widening between the second contacting portion 1222 and the narrow end portion 1236, the opposite longitudinal rims of the spring element 1220 may be parallel.

[0067] The Figures 14 and 15 show an alternative type of spring element to the type shown in the Figures 13 and 14. Figure 14 shows a perspective view of the spring element 1420. Figure 15 shows side views of the three different sides of the spring element, wherein from one to the next subfigure, the spring element is rotated by 90°. The following description of the spring element 1220 refers both to Figure 12 and to Figure 13, focusing on the differences between spring element 1420 and spring element 1220 shown in the Figures 12 and 13.

[0068] Like the spring element type shown in the Figures 12 and 13, the spring element 1420 is made of a single piece of a conductive and resilient material. Also, it is formed as a flat spring having a first bend 1423 and a second bend 1424 pointing to opposite directions. In contrast to the spring element type shown in the Figures 12 and 13, spring element 1420 has no protrusions projecting from the bends. Therefore, the first contacting portion 1421 and the second contacting portion 1422 are formed as line contacts running along the first bend 1423 and the second bend 1424. Contacting portions formed as bulges secure a localized, precise and reliable contact of the spring element with the shielding elements of the socket and the cable head. On the other hand, without protrusions such as bulges for contacting portions, the production of the spring element may be facilitated as a production step is omitted.

[0069] Like the spring element type shown in the Figures 12 and 13, the spring element 1420 has a flat end portion 1426. There is a third bend between the flat end portion 1433 and the remainder of the spring element 1420. However, in contrast to the spring element type shown in the Figures 12 and 13, there is no opening between the flat end portion 1426 and the first contacting portion 1422. On each of the longitudinal sides of the spring element 1420, there is a pair of teeth 1229a, 1230a, and respectively, 1229a, 1230b protruding from the rim of the flat end portion 1226, and additionally, a rectangular protrusion 1431a, and 1431 b, for being at least partially pressed into the material of the plug connector frame. There may be other arrangements of protrusions on the rim of the flat end portion, for example two rectangular protrusions on each side instead of one rectangular protrusion and two teeth.

[0070] The present invention is not limited to the types of spring elements shown in the Figures 10 to 13. In particular, features of the different types of spring elements shown therein may be combined. A spring element made of one piece is robust and can be easily and feasibly produced. However, the spring element need not necessarily be made of one piece of the conductive and resilient material as, for instance, the flat end portion and the remaining portion of the spring element may be welded together. Furthermore, the spring element may consist of two parts made of different materials being attached to each other, for example, by gluing or welding them

together.

[0071] In addition to plug connector and the plug connector system consisting of the plug connector, a cable head, and a socket, the present invention also provides a method for manufacturing a plug connector for accommodating a cable head end for being inserted into a socket. The method steps are illustrated in the flowchart shown in Figure 16. Accordingly, the method for manufacturing a plug connector comprises the method step 1601 of providing a plug connector frame 1601. Therein, the plug connector frame has a front opening for accommodating a cable head, a front opening for inserting a spring element, and a side wall. Furthermore, the method comprises the method step 1602 of providing a spring element made of a resilient material for electrically conductively connecting the cable head and the socket. Therein, the spring element has a first contacting portion for conductively contacting the cable head and the second contacting portion for conductively contacting the socket. Furthermore, the first contacting portion and the second contacting portion point into opposite directions and are directly and conductively connected. The method further comprises the step 1603 of inserting the spring element into the plug connector frame through the front gap, wherein the spring element is reversibly deformed. As a result of the insertion, the first contacting portion emerges inwards over the side wall of the plug connector frame, and the second contacting portion emerges outwards over the side wall of the plug connector frame.

[0072] The method step of inserting the spring element into the plug connector frame is illustrated in Figure 17. The figure shows a spring element 1720a which has been partially inserted into the plug connector frame 1710 through the front gap 1714 in the front face 1712. When the second contacting portion 1722 of the spring element passes the front gap and moves into the plug connector frame 1710, a force is exerted on the spring element1720a, and the spring element 1720a is reversibly deformed by mechanical stress resulting from the force. The spring element 1720a is formed to be able to bear enough deflection for passing of the front gap, while the deflection of the spring element during the insertion is linear and reversible. In other words, the spring element is not subject to permanent, deformation, i.e. plastic deformation. The reversible deflection of the spring element and the avoidance of plastic deformation are secured through the forming of the spring element 1720a and through the choice of a resilient material. In particular, forming features allowing a reversible deflection have been discussed in the context of different types of spring elements shown in the Figures 12 to 15. They include the tapering between the first contacting portion and the second contacting portion 1221 and the second contacting portion 1222 as well as the opening 1228 from the Figures 12 and 13. Analogously to the insertion of spring element 1720a into the plug connector frame, a second spring element 1720b has been partially inserted into the plug connector frame.

[0073] A plug connector frame resulting from the manufacturing method described above with reference to the Figures 14 and 15 is suitable for use in the assembly of a plug connector system comprising the plug connector frame, a cable head, and a socket. By comprising a spring element for connecting the shielding element of the socket (for example a plate) and the shielding element of a cable head (for example a fixation element with a crimp section), the plug connector is suitable for use with a shielded cable such as an STP cable. However, a similar plug connector can be used when connecting an unshielded cable, such as a UTP cable, to a socket. In the case of an unshielded cable, the same type of plug connector frame can be used as a plug connector, without spring. In addition, the socket used in the plug connector system can be used for an unshielded cable as well. The use of a socket that is equal in the cases of an unshielded and a shielded cable and plug connectors that are similar for the two cases allow an economic and flexible assembly. On the one hand, shielded cables and unshielded cables may be combined in an economic way. On the other hand, it may still be decided at a late stage of assembly whether an unshielded cable or a shielded cable is preferred for a particular application.

[0074] The suitability of the plug connector system according to an aspect of the present invention has been tested. In particular, the plug connector system has been used as a demonstrator system for a comparison of the EMC performance of a high balanced UTP cable, a standard STP cable, and a high balanced STP cable. Cross sections of the three different cables are illustrated on the right hand side of Figure 18. The high balanced STP cable differs from the standard STP cable by an inner jacket embedding the wires. The high balanced UTP cable used in the test fulfills the mode conversion requirements for automotive single pair unshielded 1 Gbit/s applications. It was used as a reference.

[0075] A stripline test setup was used for measuring the EMC performance. The twisted pair cable was stimulated with the differential signal (i.e., the signaling mode used for data communication). The common mode signal at the stripline versus ground (i.e., the noise signal) was measured at the output. The transfer of function between the data mode and noise mode was calculated by a vector and network analyzer (VNA). The resulting S-parameter in dB is the value for assessment of the EMC capability. The test results are shown in Figure 18. The S-parameter in dB is shown as a function of the differential signal in MHz. The results illustrate that the standard STP cable shows a lower performance for certain frequency ranges, as indicated by the arrow. High balanced shielded, cables, on the other hand, provide an improvement of about 10 to 20 dB.

[0076] Summarizing, the present invention relates to a plug connector 100 for accommodating a cable head 130 and for being inserted into a socket 160. The plug connector 100 can be used for economically and feasibly integrating shielded cables into unshielded data commu-

nication systems, for example for sensitive links in automotive applications where a high electromagnetic compatibility (EMC) is required. The plug connector comprises a plug connector frame 110 and a connection member for electrically conductively connecting the shielding elements of the socket and the cable head 130. Advantageously, the connection member is a spring element 120 made of a resilient material having two contacting portions for electrically conductively contacting shielding elements of the cable head 130 and the socket 160. A method for manufacturing a plug connector is also provided.

Reference signs:

[0077]

100	plug connector
110	plug connector frame
111	front portion
112	front face
113	front opening
114	front gap
114a,b	front gaps
115a,b,c,d	grooves
116	side wall
116a,b	side walls
117	side wall opening
120	spring element
120a,b	first and second spring element
121	first contacting portion
121a,b	first contacting portions of respective spring elements
122	second contacting portion
122a,b	second contacting portions of respective spring elements
130	cable head
131	shielded cable
132	fixation element
133	crimp section
134	contact insert
160	socket
161	socket body
162	plate
162a,b	plates
234	fixing means
317a,b	side wall hole edge
318	outer side wall
323	flat end portion
323a,b	flat end portions
324a,b,c,d	projections
325a,b	narrow end portion
333	first bend
334	second bend
563	socket wall
634a,b	current carriers
690	dashed line symbolizing current path
1129a,b	teeth
1220	a spring element
1221	first contacting portion
1222	second contacting portion
1223	first bend
1224	second bend
1225	third bend
1226	flat end portion
1228	opening
1229a,b	teeth
1234a,b	protrusions
1236	narrow end portion
1237a,b	guiding features
1420	a spring element
1421	first contacting portion
1422	second contacting portion
1423	first bend
1424	second bend
1426	flat end portion
1429a,b	teeth
1430a,b	teeth
1431a,b	rectangular protrusions
1601	step of providing plug connector frame
1602	step of providing spring element
1603	insertion step
1710	plug connector frame
1712	front face
1714	front gap
1720a,b	spring elements
1722	second contacting portion

Claims

1. A plug connector (100) for being inserted into a socket (160) and for accommodating a cable head (130), the plug connector (100) comprising:

a plug connector frame (110) having a side wall (116) and a front opening (113) for accommodating the cable head (130),
a spring element (120) made of a resilient material for electrically connecting the cable head (130) and the socket (160), the spring element (120) having:

a first contacting portion (121) projecting inwards above the side wall (116) of the plug connector frame (110) for electrically conductively contacting the cable head (130), and
a second contacting portion (122) projecting outwards above the side wall (116) of the plug connector frame (110) for electrically conductively contacting the socket (160),

the first contacting portion (121) and the second contacting portion (122) being directly and electrically conductively connected.

2. The plug connector according to claim 1, wherein the spring element (120) is formed as a flat spring having two bends (1223, 1224), the bends oriented to opposite directions, and the contacting portions being located at the bends.

3. The plug connector according to claim 2, wherein the two contacting portions (1221, 1222) are bulges coined into the spring element (120) at the bends, wherein the bulge constituting the first contacting portion (1221) is oriented towards the interior of the plug connector frame (110) and the bulge constituting the second contacting portion (1222) is oriented towards the exterior of the plug connector frame (110).

4. The plug connector according to any of claims 1 to 3 wherein the spring element comprises a flat end portion (323a) fitted into a portion of the plug connector frame adjacent to a front face (112) including the front opening (113), and a protrusion (324a) for fixing the spring element (120a) in the plug connector frame (110), the protrusion (324a) projecting from a surface of the flat end portion.

5. The plug connector according to claim 4, wherein the protrusion (324a) projecting from the flat end portion (323a) of the spring element is a bulge coined into the flat end portion (323a) of the spring element.

6. The plug connector according to claim 4 or 5, wherein a tooth (1229a) protrudes from a rim of the flat end portion (323a) of the spring element (120) for fixing the spring element (120) into the plug connector frame (110), the tooth (323a) being at least partially pressed into the material of the plug connector frame (110).

7. The plug connector according to any of claims 1 to 6, wherein the spring element (120) is made of a single piece of the resilient material.

8. The plug connector according to any of claims 1 to 7, wherein the spring element (120) is made of metal.

9. The plug connector according to any of claims 1 to 8 wherein a contacting portion of the spring element (120) is plated, wherein the material of the plating has a higher electrical conductivity than the material of which the spring element is made.

10. The plug connector according to any of claims 1 to 9, wherein the plug connector frame (110) has a front gap (114) for inserting the spring element.

11. The plug connector according to claim 10, wherein the front gap (114) and the front opening (113) of the plug connector frame are joined.

12. The plug connector according to any of claims 10 or 11, wherein the first contacting portion (121) and the second contacting portion (122) of the spring element emerge over the side wall (116) through a side wall opening (117), the side wall opening (117) and the front gap (114) being joined.

13. The plug connector according to any of claims 1 to 12, wherein the plug connector comprises a second spring element (120b) fitted into a second side wall (116b) of the plug connector frame on the opposite side of the plug connector frame from the side wall (116a) into which the first spring element (120a) is fitted.

14. A plug connector system comprising a socket (160), a plug connector (100) according to any of claims 1 to 13, and a cable head (130) of a shielded cable (131),
the socket (160) comprising a shielding element made of an electrically conductive material,
the cable head (130) comprising a shielding element made of an electrically conductive material, and
the spring element (120) of the plug connector electrically connecting the shielding element of the socket and the shielding element of the cable head,
wherein the plug connector (100) is detachably insertable into the socket (160) and the cable head (130) is non-detachably inserted into the plug connector (100).

15. A method for manufacturing a plug connector, comprising the method steps of:

providing (1601) a plug connector frame having a front opening for accommodating a cable head, a front gap for inserting a spring element, and a side wall,
providing (1602) a spring element made of a resilient material for electrically conductively connecting the cable head and the socket,
the spring element having a first contacting portion for electrically conductively contacting the cable head and
a second contacting portion for electrically conductively contacting the socket,
the first contacting portion and the second contacting portion pointing into opposite directions and being directly and electrically conductively connected, and
inserting (1603) the spring element into the plug connector frame through the front gap so that the first contacting portion projects inwards above the side wall of the plug connector frame and the second contacting portion projects outwards above the side wall of the plug connector frame, reversibly deforming the spring element during insertion.

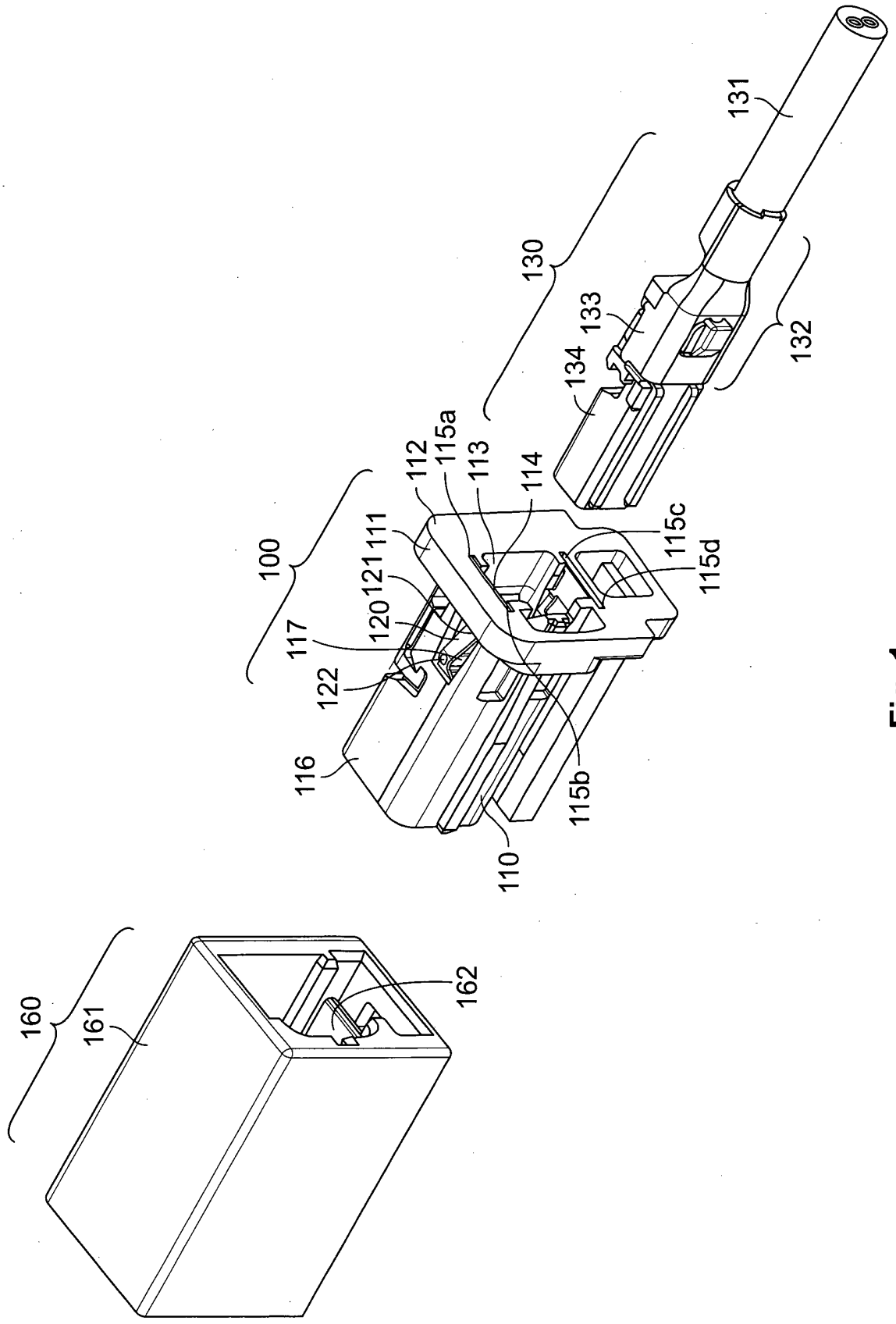
160
161
162
100
110
111
112
113
114
115a
115b
115c
115d
116
117
120
121
122
130
131
132
133
134

Fig. 1

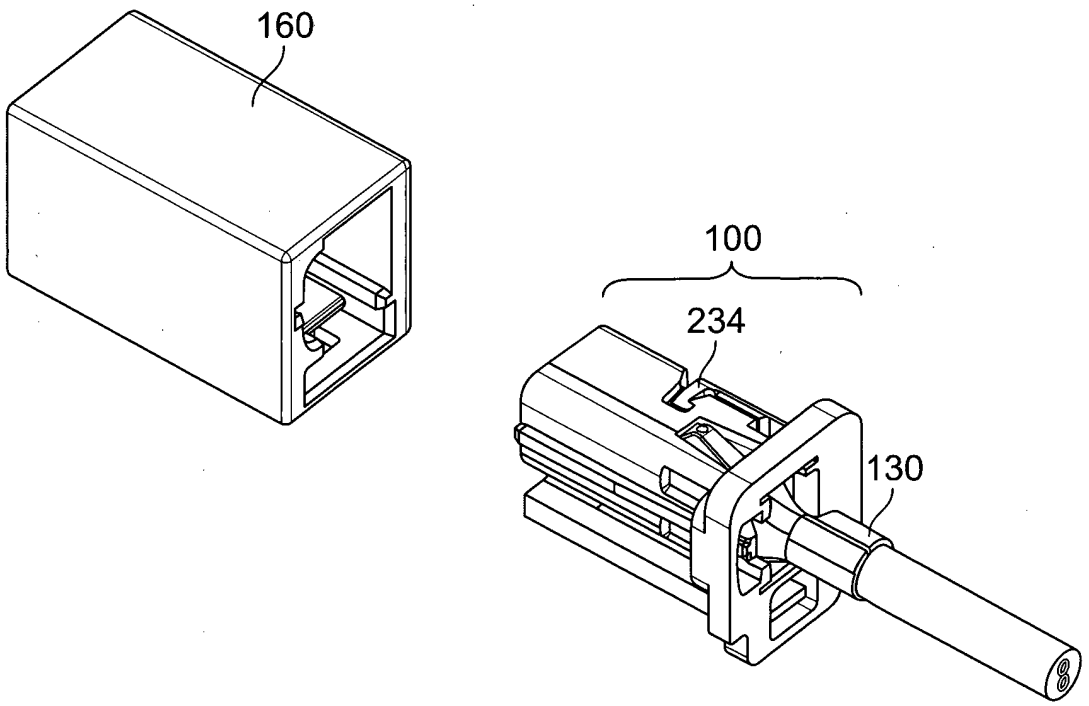
160
100
234
130

Fig. 2

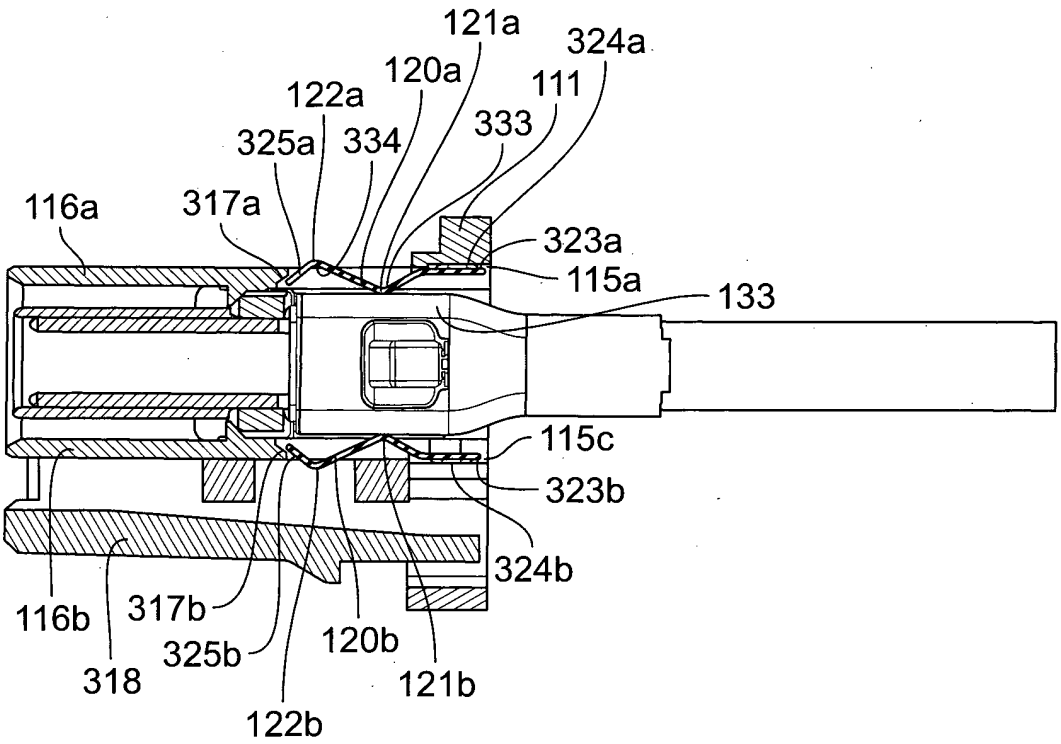
121a
324a
120a
111
122a
333
325a
334
116a
317a
323a
115a
133
115c
323b
324b
116b
317b
325b
120b
318
121b
122b

Fig. 3

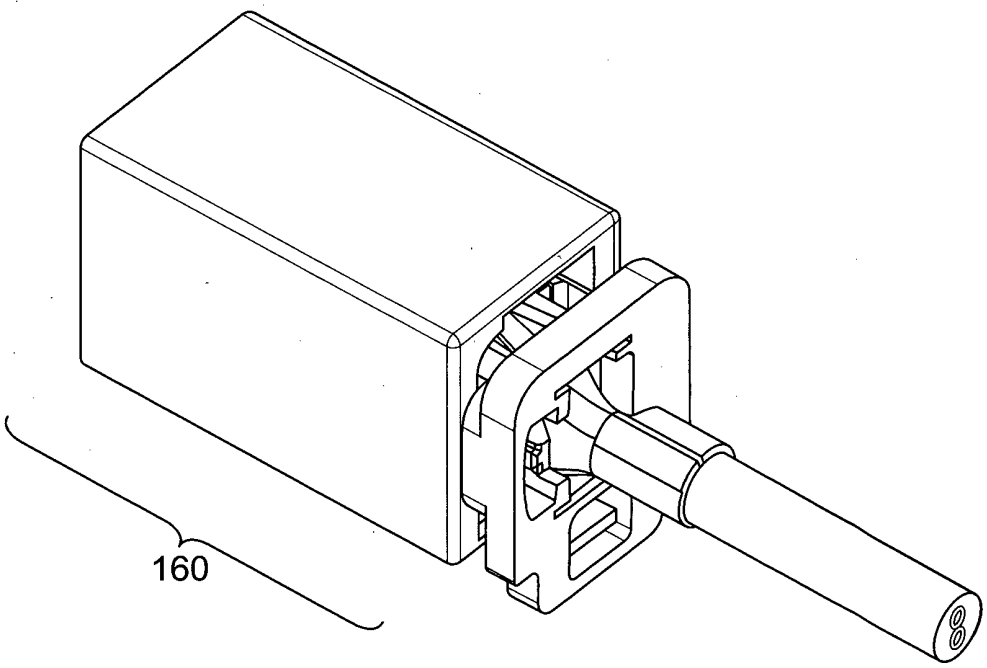

Fig. 4

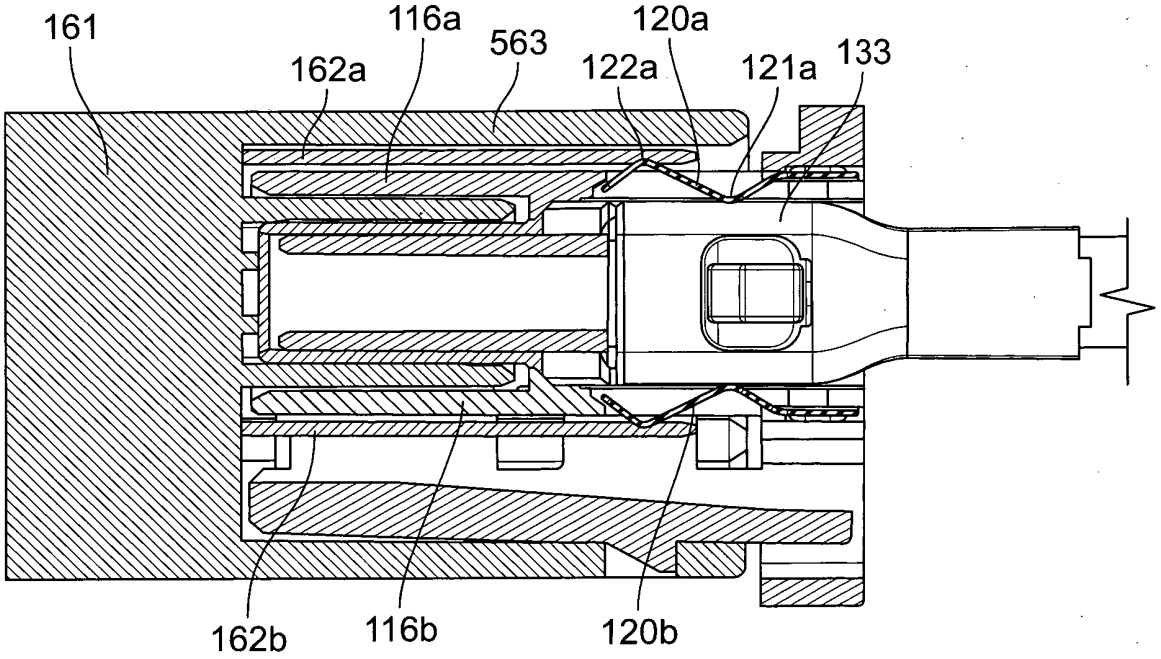

Fig. 5

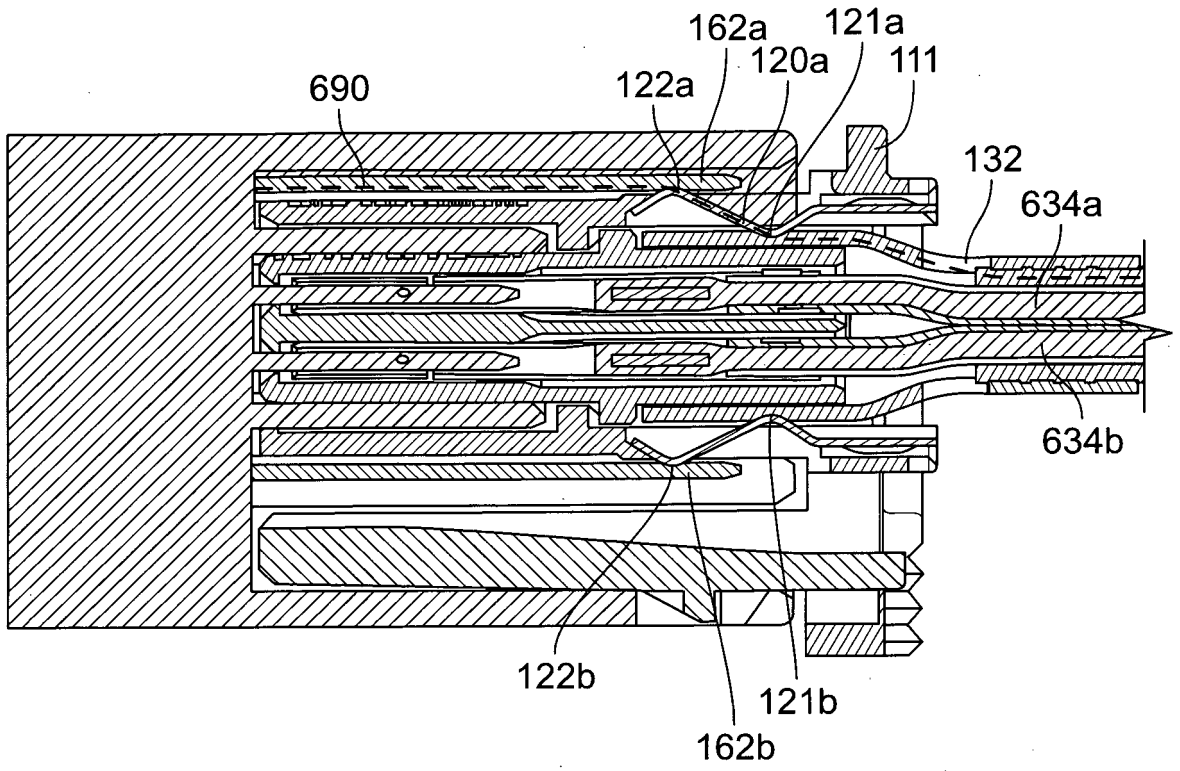
690
162a
121a
120a
122a
111
132
634a
634b
122b
121b
162b

Fig. 6

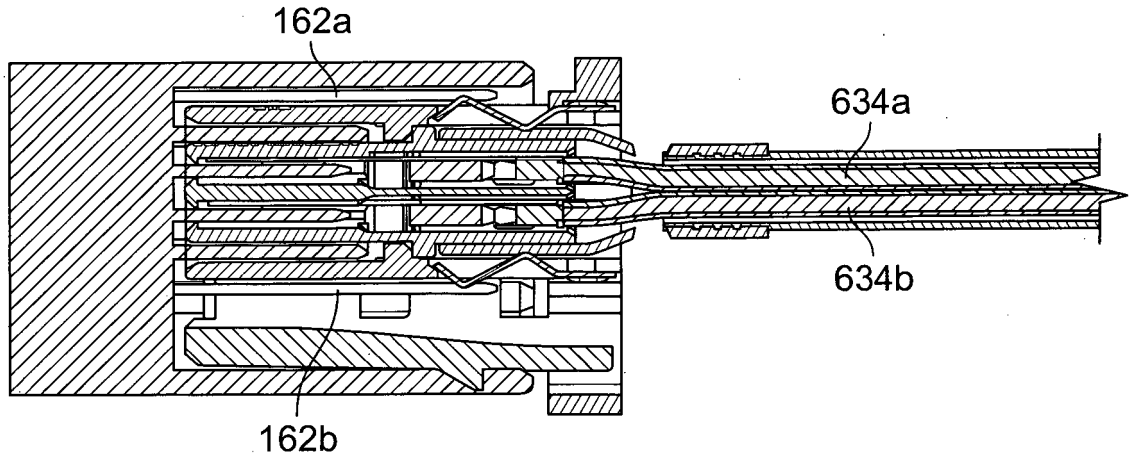
162a
634a
634b
162b

Fig. 7

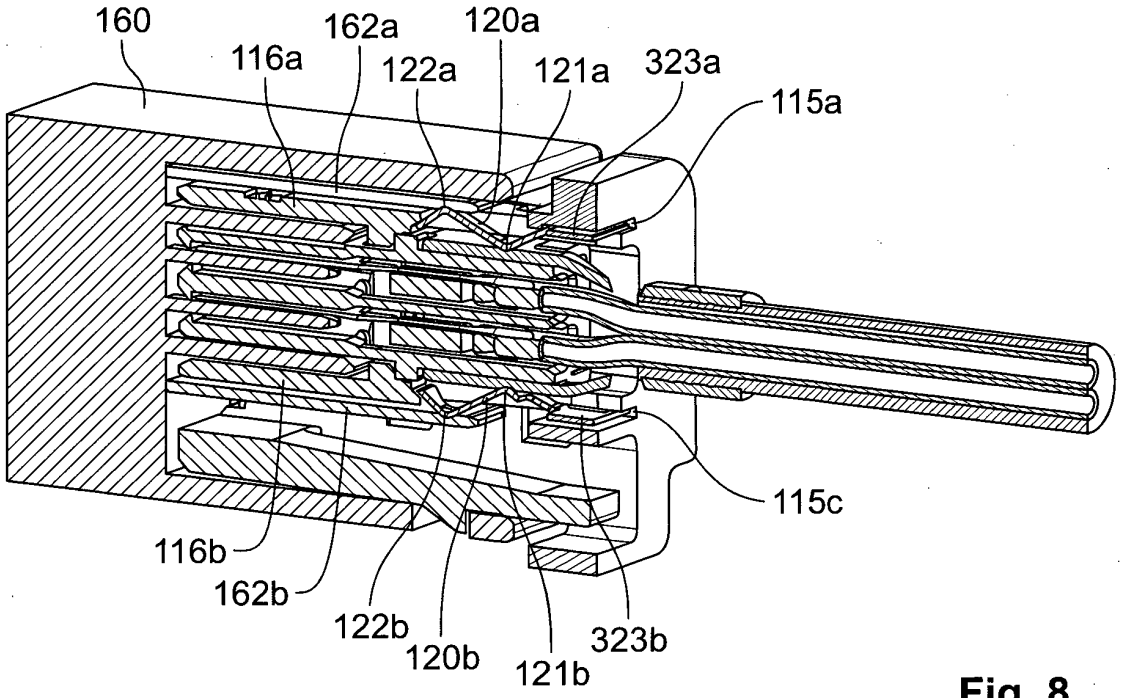
160
116a
162a
122a
120a
121a
323a
115a
115c
116b
162b
122b
120b
121b
323b

Fig. 8

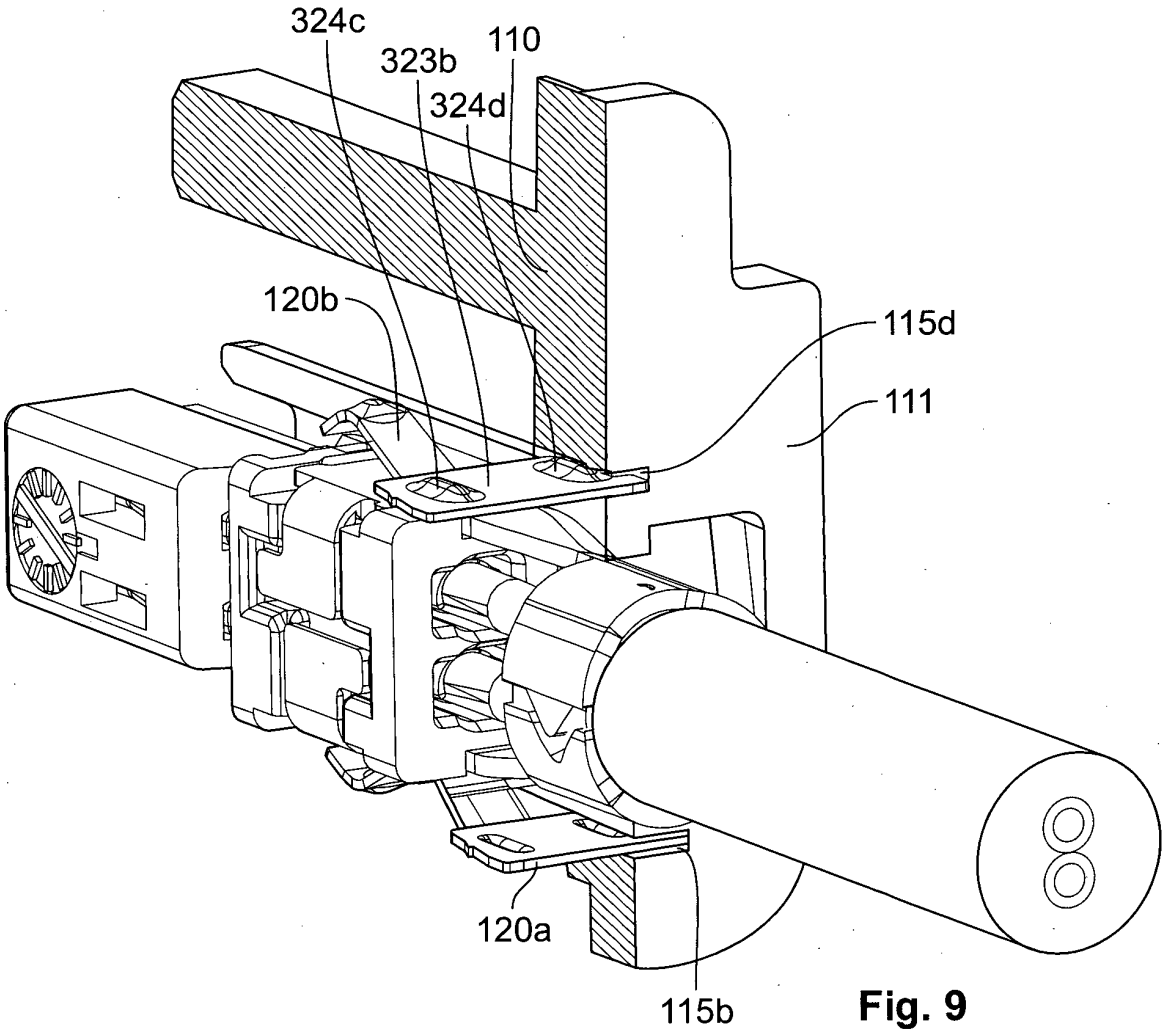
324c
323b
110
324d
120b
115d
111
120a
115b

Fig. 9

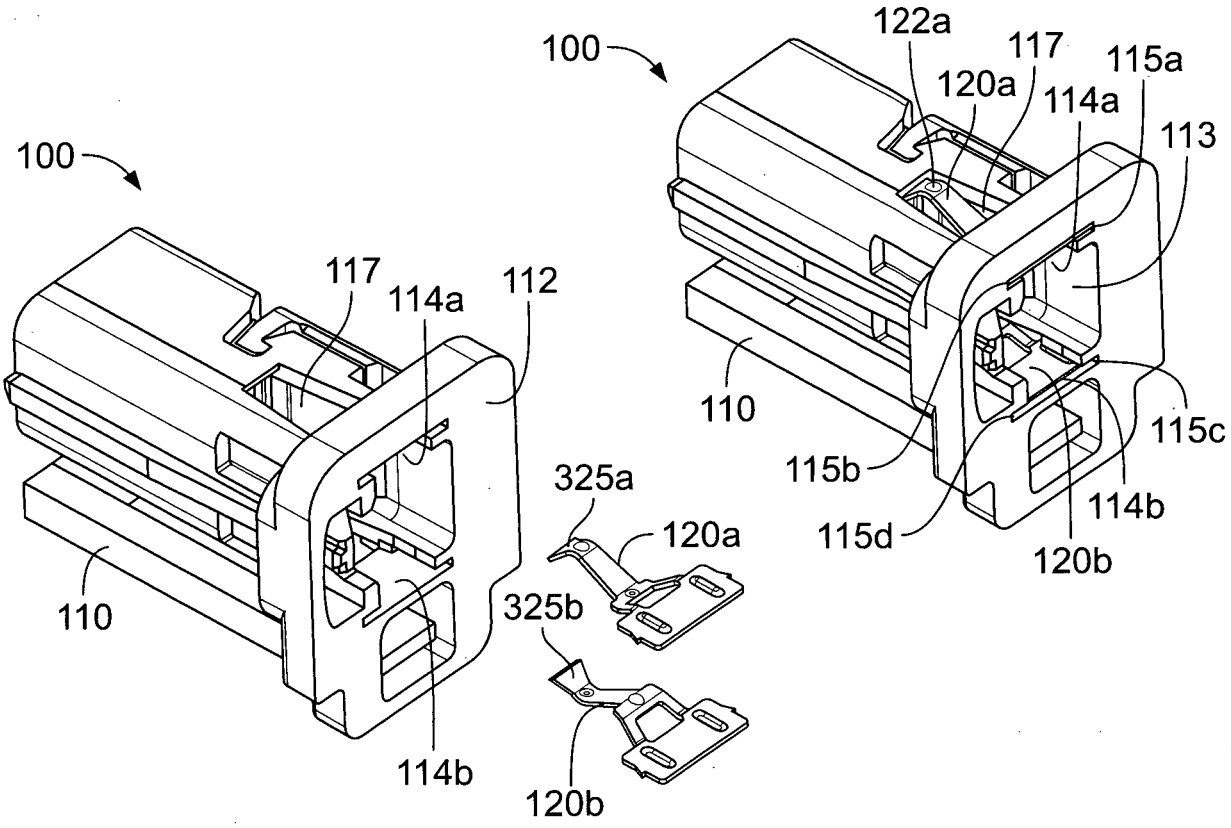
100
117
114a
112
110
114b
325a
120a
325b
120b
100
122a
117
120a
115a
114a
113
110
115c
115b
114b
115d
120b

Fig. 10

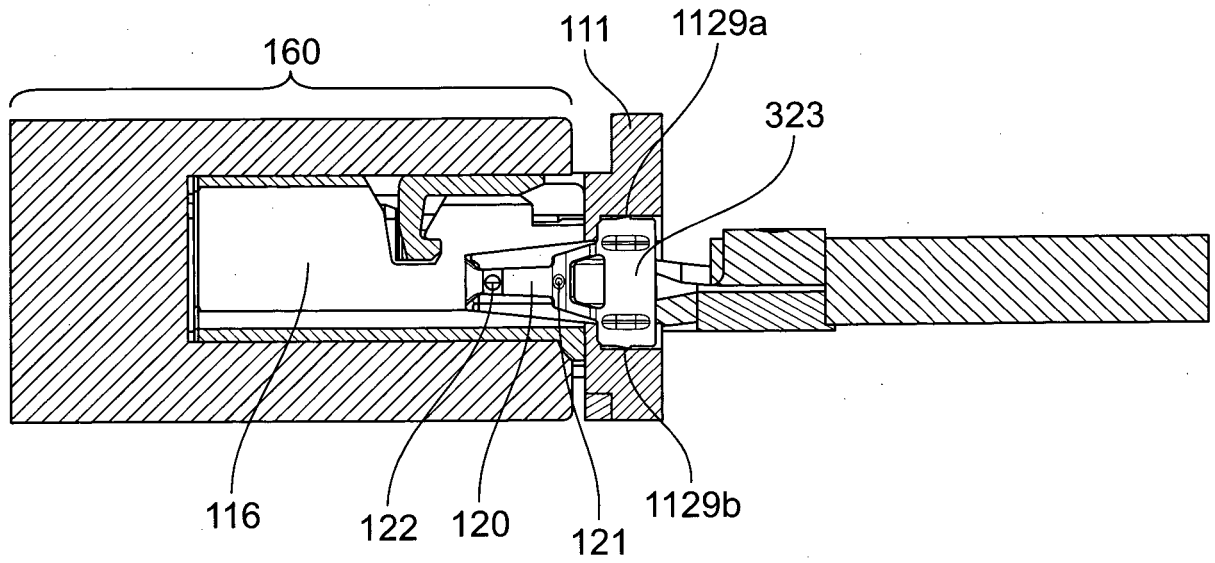
160
111
1129a
323
116
122
120
121
1129b

Fig. 11

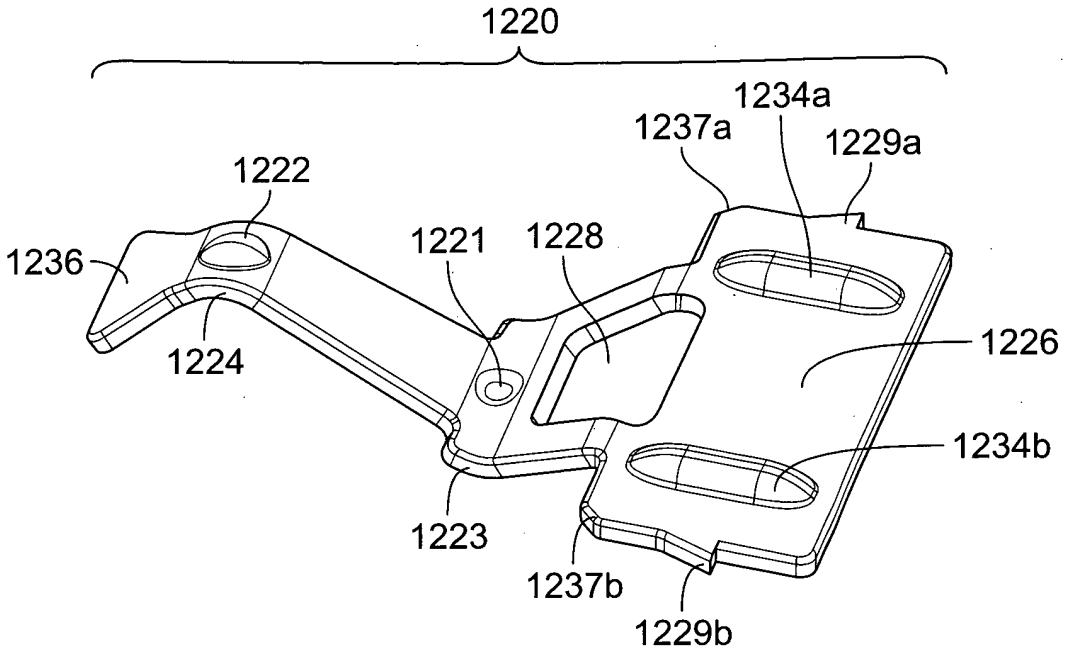
1220
1234a
1237a
1229a
1222
1236
1221
1228
1226
1224
1234b
1223
1237b
1229b

Fig. 12

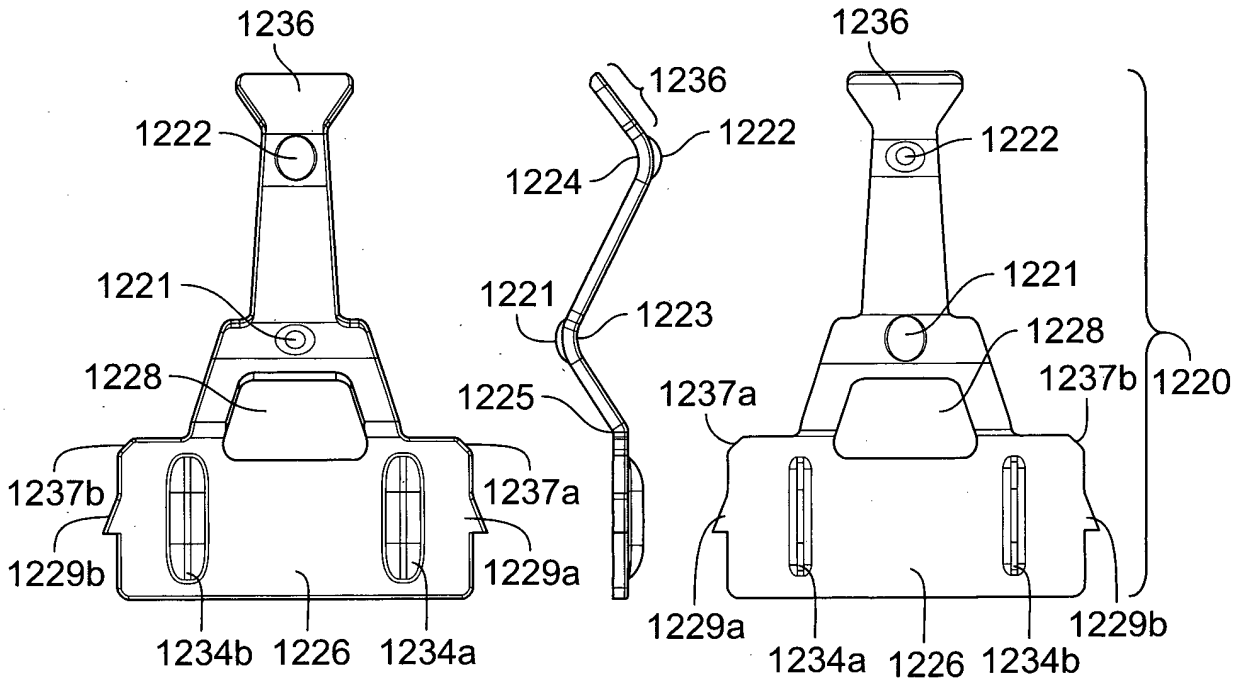
1236
1222
1221
1228
1237b
1237a
1229b
1229a
1234b
1226
1234a
1236
1222
1224
1221
1223
1225
1236
1222
1221
1228
1237a
1237b
1220
1229a
1234a
1226
1234b
1229b

Fig. 13

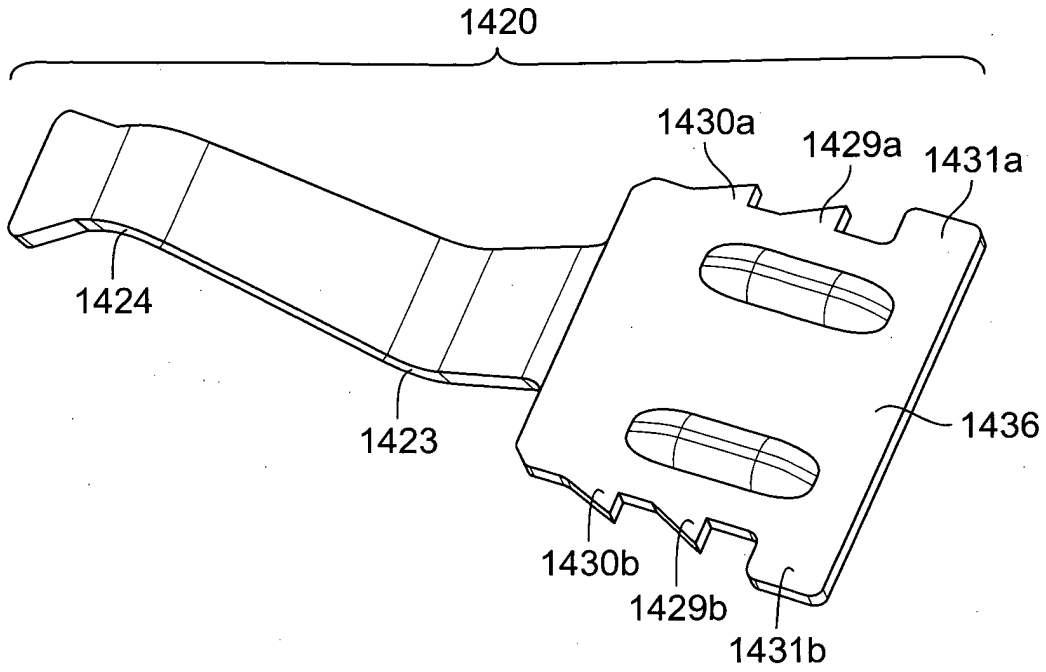
1420
1430a
1429a
1431a
1424
1423
1436
1430b
1429b
1431b

Fig. 14

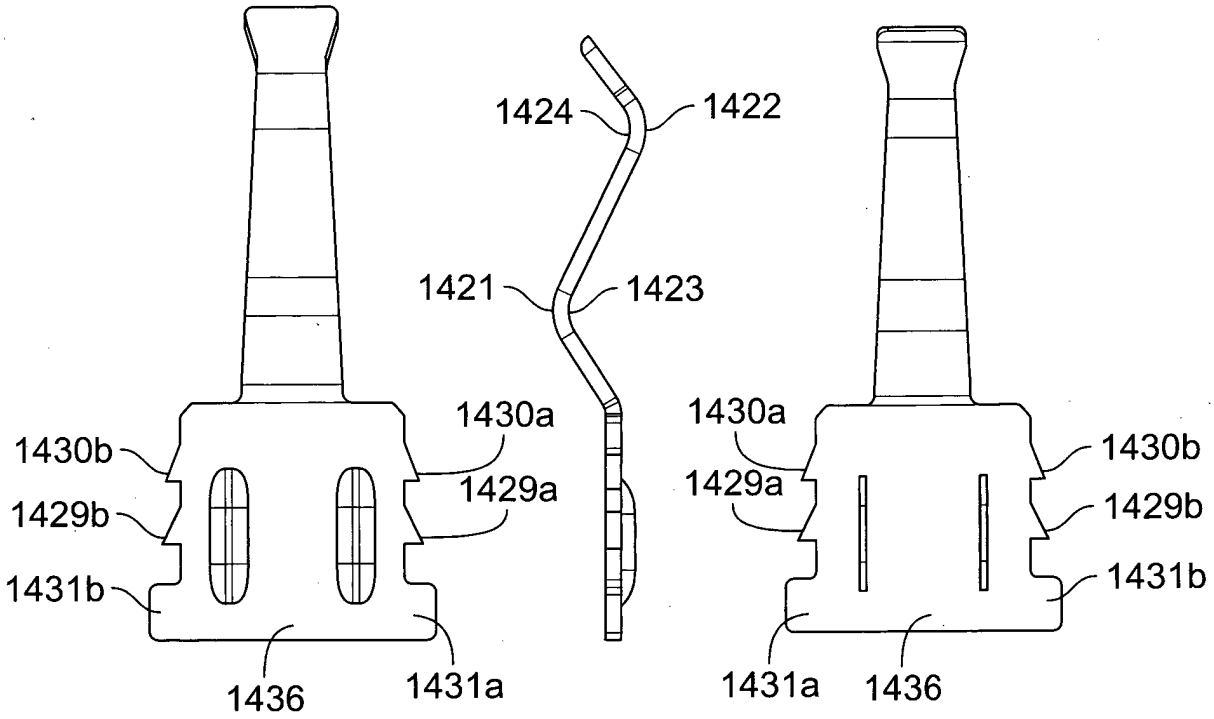
1424
1422
1421
1423
1430b
1429b
1431b
1430a
1429a
1436
1431a
1430a
1429a
1430b
1429b
1431b
1431a
1436

Fig. 15

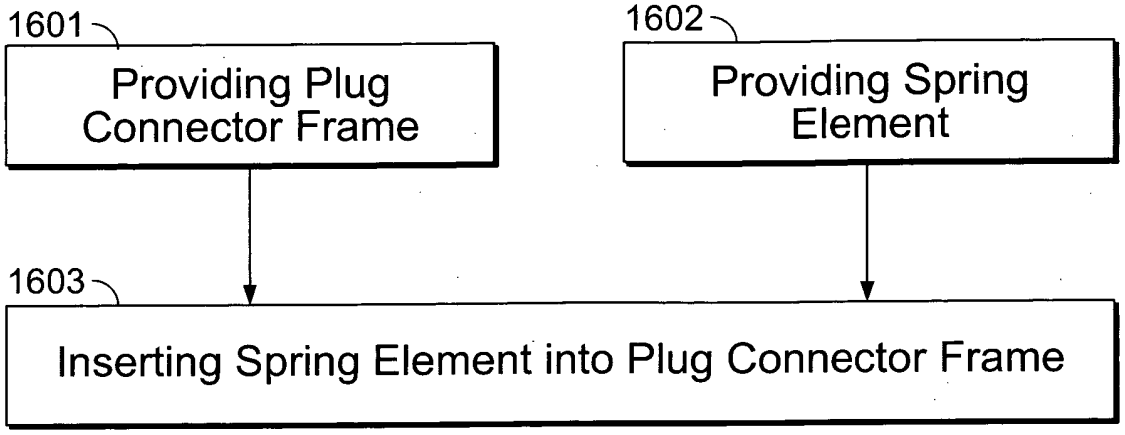
1601
Providing Plug Connector Frame
1602
Providing Spring Element
1603
Inserting Spring Element into Plug Connector Frame

Fig. 16

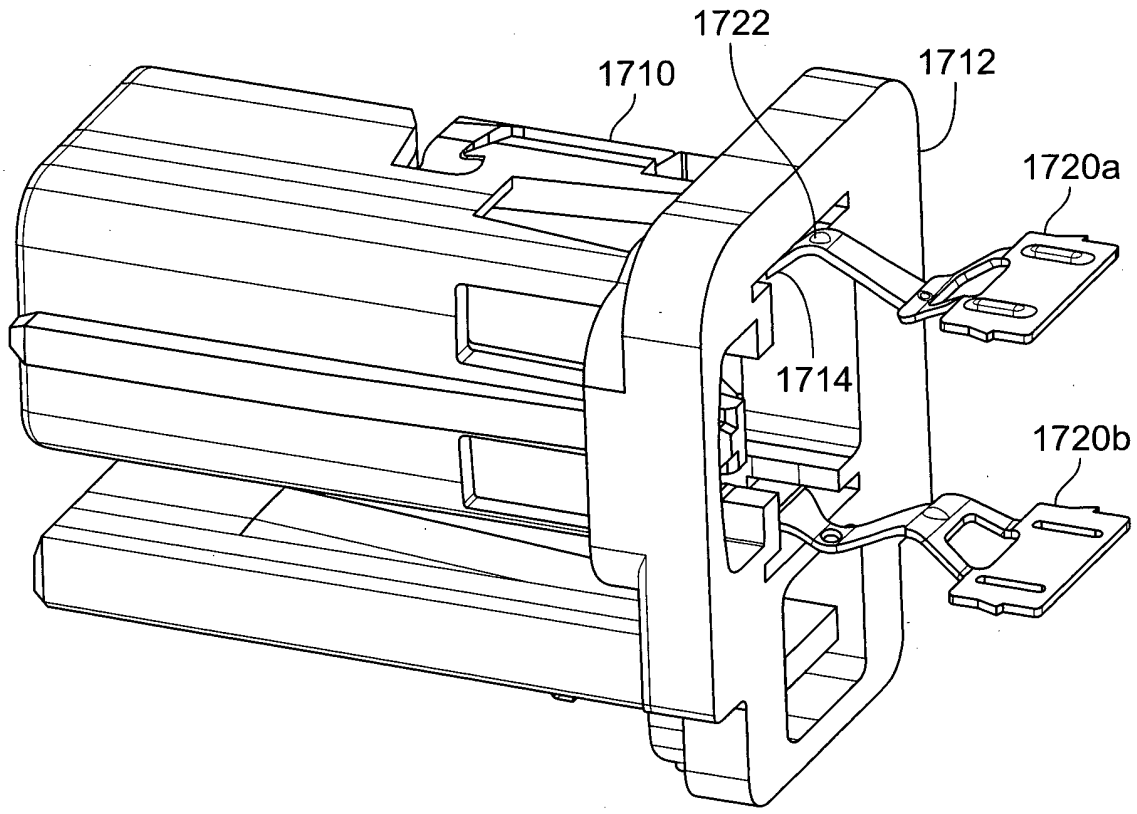
1722
1710
1712
1720a
1714
1720b

Fig. 17

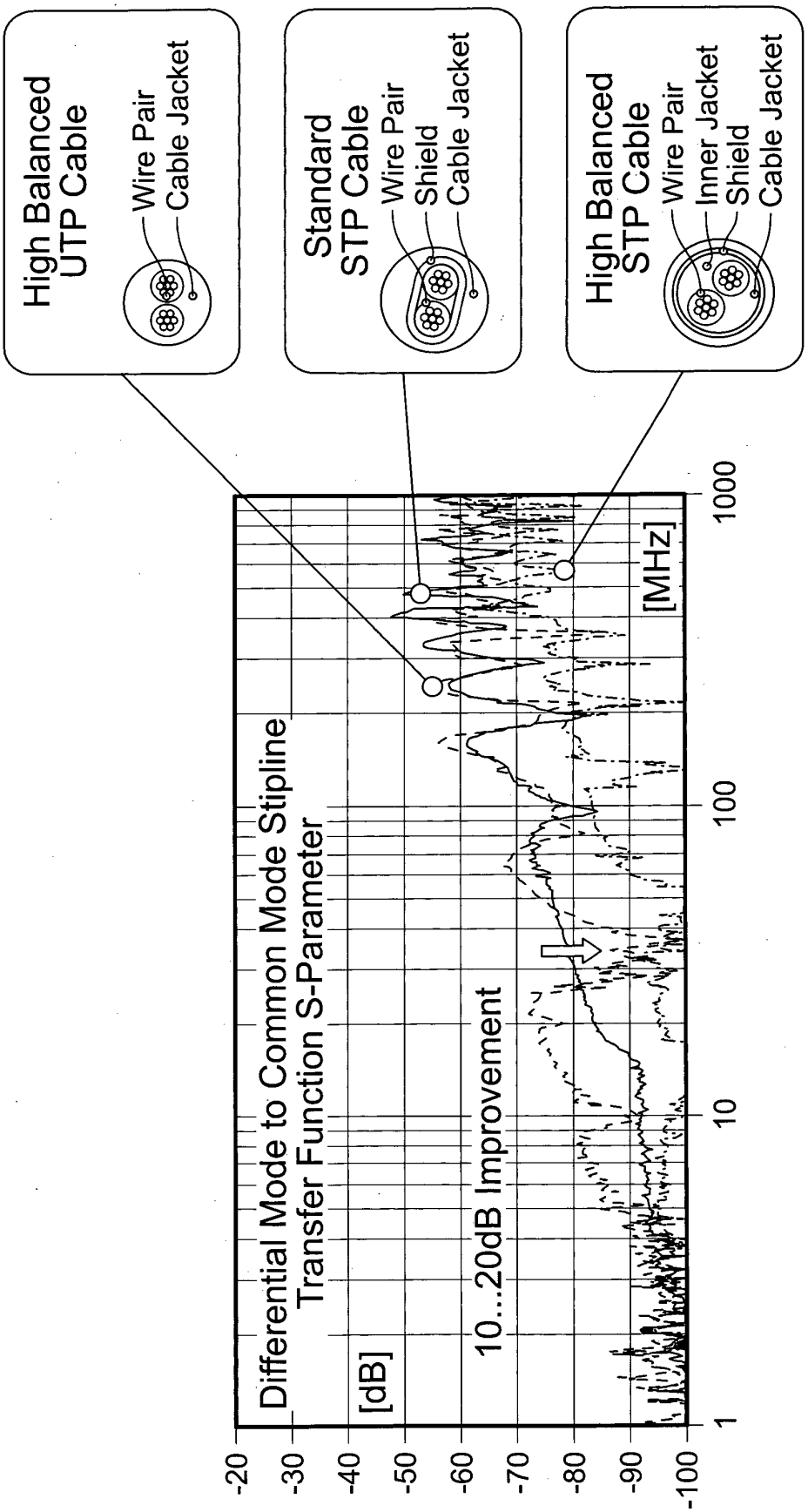
High Balanced UTP Cable
Wire Pair
Cable Jacket
Standard STP Cable
Wire Pair
Shield
Cable Jacket
High Balanced STP Cable
Wire Pair
Inner Jacket
Shield
Cable Jacket
Differential Mode to Common Mode Stipline
Transfer Function S-Parameter
[dB]
[MHz]
10...20dB Improvement
-20
-30
-40
-50
-60
-70
-80
-90
-100
1
10
100
1000

Fig. 18

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 2912

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H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 March 2017	Georgiadis, Ioannis

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L : document cited for other reasons

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